FTD-ID(RS)T-0487-90

# FOREIGN TECHNOLOGY DIVISION





SOLID PROPELLANT BALLISTIC MISSILE (References)

bу

A.M. Sinyukov, L.I. Volkov, et al.



Approved for public release; Distribution unlimited.

AD-A225 308

## PARTIALLY EDITED MACHINE TRANSLATION

FTD-ID(RS)T-0487-90

27 June 1990

MICROFICHE NR: FTD-90-C-000673

SOLID PROPELLANT BALLISTIC MISSILE (References)

By: A.M. Sinyukov, L.I. Volkov, et al.

English pages: 11

Source: Ballisticheskaya Raketa na Tverdom Topliv,

Publishing House "Voyennoye", Moscow, 1972,

pp. 502-507

Country of origin: USSR

This document is a machine translation.

Input by: Young H. Perry

Merged by: Patricia K. Williams Requester: FTD/TTTR/Capt Dawn A. Adams

Approved for public release; Distribution unlimited.

THIS TRANSLATION IS A RENDITION OF THE ORIGI-NAL FOREIGN TEXT WITHOUT ANY ANALYTICAL OR EDITORIAL COMMENT STATEMENTS OR THEORIES ADVOCATED OR IMPLIED ARE THOSE OF THE SOURCE AND DO NOT NECESSARILY REFLECT THE POSITION OR OPINION OF THE FOREIGN TECHNOLOGY DIVISION.

PREPARED BY

TRANSLATION DIVISION FOREIGN TECHNOLOGY DIVISION WPAFB, OHIO

### U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration .	Block	Italic	Transliteration
A a	A a	A, a	Υр	Pp	R, r
5 6	Б 8	B, b	Сс	Cc	S, s
ê e	<i>B</i> •	V, v	Ττ	7 m	T, t
ר ר	Γ .	G, g	Уу	Уу	U, u
Дц	Дд	D, d	Фф	<b>Ø</b>	F, f
Еe	E .	Ye, ye; E, e∗	Х×	X x	Kh, kh
Н ж	ж	Zh, zh	Цц	U v	Ts, ts
3 э	3 ,	Z, z	4 4	4 4	Ch, ch
Ии	H	I, i	யெய	Ш щ	Sh, sh
RA	A a	Y, y	ध व	Щщ	Sheh, sheh
Н н	KK	K, k	Ъъ	3 ,	11
J. s	ЛА	L, 1	р: ы	W w	Y, y
∴ <sup>L</sup> .	Мм	N, m	ьь	<b>b</b> •	t
н н	Н к	N, n	Ээ	9 ,	E, e
- C	0 •	O, c	Юю	10 n	Yu, yu
	Пп	P, p	Я я	Я	Ya, ya

<sup>\*</sup>ye initially, after vowels, and after E, E; e elsewhere. When written as E in Russian, transliterate as yE or E.

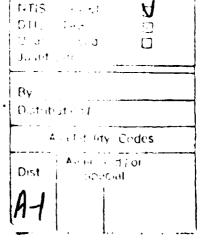
#### RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	sinh <sup>-1</sup>
cos	cos	ch	cosh	arc ch	cosh
tg	tan	th	tanh	arc th	tanh
ctg	cot	cth	coth	arc cth	coth <sup>-1</sup>
sec	sec	sch	sech	arc sch	sech <sup>-1</sup>
cosec	csc	csch	csch	arc csch	csch <sup>-1</sup>

Russian	English		
rot	curl		
lg	log		

#### GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.



Acception For



SOLID PROPELLANT BALLISTIC MISSILE (REFERENCES)
Page 502.

#### REFERENCES.

- 1. G. G. Abezgauz, A. P. Tron', Yu. N. Kopenkin, I. A. Korovina. Manual on the probabilistic calculations. Voenizdat, 1966.
- 2. A. I. Abramyan. Proceedings of AS ARM. SSR. Series of physical mat. sciences, volume 15, No. 12, 1962.
- 3. M. N. Aleshkov, I. I. Zhukov. Physical bases of rocket weapon. Voenizdat, 1965.
- 4. A. V. Amel'yanchik, V. T. Lapteva, Ye. P. Strunina. Solution of the two-dimensional axisymmetric temperature problems of the theory of elasticity, elastoplastic strains and creep computer(s) "Ural-2". In the collection "Thermal stresses in the elements of constructions", Iss. 7, Kiev, "Naukova Dumka", 1967.
- 5. L. Ye. Anapol'skaya. Mode of wind velocities to territory of the USSR. L., Gidrometeoizdat, 1961.
- 6. R. F. Appazov, S. Lavrov and V. P. Mishin. Ballistics of the controlled long-range rockets. "Science", 1966.
- 7. Aspects of reliability during design of powerful steps/stages with RDTT [РДТТ solid-propellant rocket engine] "Astronautics and rocket dynamics". Express-information. VINITI [ВИНИТИ All-Union Institute of Scientific and Technical Information], 1964, No. 47, abstract 217.
- 8. Yu. D. Akhenbakh. Dynamic behavior of a long fastened with the housing viscoelastic cylinder. Rocket engineering and cosmonautics. Russian translation, No. 4, 1965.

9. V. L. Bazhanov, I. I. Gol'denblat, V. A. Kopnov, A. D. Pospelov, A. M. Sinyukov. Resistance of glass-fiber-reinforced plastics, M., Machine building, 1968.

- 10. I. Bazovskiy. Reliability. Theory and practice. "Mir", 1965.
- 11. L. I. Balabukh, K. S. Kolesnikov, V. S. Zarubin, A. Alfutov,
- V. I. Usyukin, V. F. Chizhov. Bases of structural mechanics of rockets. M., Higher School, 1969.
- 12. M. Barrer, A. Zhomott, B. F. Vebekh, Zh. Vandenkerkkhove.
  Rocket engines. Oborongiz, 1962.
- 13. N. I. Bezukhov, V. L. Bazhanov, I. I. Gol'denblat, N. A. Nikolayenko, A. M. Sinyukov. Calculations for strength, stability and oscillations/vibrations at high temperatures. M., Machine building, 1965.
- 14. N. I. Bezukhov. Bases of the theory of elasticity, plasticity and creep, M., Higher school, 1961.
- 15. K. U. Besserer. Engineering manual on guided missiles. Voenizdat, 1962.
- 16. I. A. Birger. Circular plates and shells of revolution. M., Oborongiz, 1961.
- 17. I. A. Birger. Some mathematical methods of solving the engineering problems. M., Oborongiz, 1956.

Page 503.

- 18. V. V. Bolotin. Statistical methods in structural mechanics. Stroyizdat, 1965.
- 19. L. N. Bol'shev and N. V. Smirnov. Table of mathematical

statistics. Science, 1965.

20. S. V. Boyarshinov. Some technical applications of theory of the axially symmetric deformation of thin-walled cylindrical shell. In the coll. Stress analyses. Iss. 6. M., Mashgiz [Mamru3 - State Scientific and Technical Publishing House of Literature on Machinery Manufacture], 1960.

- 21. N. P. Buslenko, Yu. A. Shreyder. Method for statistical testing (Monte Carlo) and its realization in the digital computers. Fizmatgiz, 1961.
- 22. R. Busch and F. Mosteller. Stochastic models of learning ability. Fizmatqiz, 1962.
- 23. D. L. Bykov. On one method of determining stresses and strains in the linear-viscoelastic bodies. Engineering journal "Mechanics of solid", No. 2, 1968.
- 24. Lianis, Vzlanis. Method of the study of the unsteady thermal stresses in thermorheologically simple viscoelastic bodies. Applied mechanics, No. 1, 1964 (Russian translation).
- 25. V. I. Bartholomeyev and M. I. Kopytov. (ed.). Design and testing ballistic missiles. Voenizdat, 1969.
- 26. Ye. Venttsel'. Introduction to operations research. "Sov. radio", 1964.
- 27. Ye. Venttsel'. Probability theory. "Science", 1964.
- 28. G. Wilson. "Rocket engineering and cosmonautics", 1961, No. 6 and 1964, No. 7.
- 29. M. L. Williams. Effect of mechanical properties on the construction of engines on solid fuel. Publ. of foreign lit., 1963.

30. V. Z. Vlasov. General theory of shells. State Technical Press, 1949.

- 31. Questions of rocket equipment No. 6, 1963; No. 1, 6, 1964; No. 1, 5, 1966; No. 2, 1967; No. 2, 3, 7, 9, 1968.
- 32. "Questions of rocket engineering", 1969, No. 9.
- 33. F. R. Gantmakher. Theory of matrices. Publ. 3. Nauka, 1967.
- 34. L. R. Herman, M. Tamekuni. Shrinkage of engines on solid fuel during the horizontal storage. "Rocket engineering", 1964, No. 4.
- 35. B. V. Nedenko, Yu. K. Belyayev, A. D. Solovyev. Mathematical methods in the theory of reliability. "Science", 1965.
- 36. I. I. Gol'denblat, N. A. Nikolaenko. Theory of creep of building materials and its application. State. publ. lit. on construction, architecture and building materials, 1960.
- 37. I. I. Gol'denblat, V. A. Kopnov. Criteria of strength and plasticity of structural materials. M., Machine building, 1968.
- 38. Ye. G. Goldstein and D. B. Yudin. New directions in the linear programming. "Sov. radio", 1966.
- 39. I. Bradshteyn and I. M. Ryzhik. Tables of integrals, sums, series/rows and products. Publ. 4. Fizmatgiz, 1962.
- 40. V. Ye. Gul'. Strength of polymers. Khimizdat, 1964.
- 41. B. N. Demidovich, I. A. Maron, Ye. Z. Shuvalova. Numerical methods of analysis. Publ. 2. Fizmatgiz, 1963.
- 42. B. N. Demidovich and I. A. Maron. Bases of calculating mathematics. Fizmatgiz, 1960.
- 43. G. V. Druzhinin. Reliability of the systems of automation. "Energy", 1967.

44. A. A. Il'yushin. Some questions of the theory of plastic deformations. PMM, VIII, Iss. 4, 1944.

- 45. Study of solid-propellant rocket engines. M., IIL, 1963.
- 46. A. V. Kantor. Equipment and the methods of measurements during the tests of rockets. M., Oborongiz, 1963.
- 47. Z. B. Kantorovich. Bases of the calculation of chemical machines and apparatuses. Mashgiz, 1952.
- 48. F. Kast and D. Rozentsveyg. (ed.). Science technology control. "Sov. radio", 1966.
- 49. M. J. Kendall and A. St'yuart. Distribution theory. "Science", 1966.

#### Page 504.

- 50. P. Klyuger. Precomputation of the reliability of the construction/design of very large solid-propellant rocket engines. "Questions of rocket engineering", IIL, No. 1, 1965.
- 51. P. Klyuger. Evaluation of reliability during the design of large RDTT. "Astronautics and rocket dynamics". Express-information. VINITI, 1965, No. 2, abstract 7.
- 52. G. V. Kolosov. On one application of theory of complex variable functions to two-dimensional problem of the mathematical theory of elasticity. Yur'yev, 1909.
- 53. G. Korn and T. Korn. Manual on mathematics for the scientific workers and engineers. M., "Science", 1968.
- 54. G. Cramer. Mathematical methods of statistics. IL, 1948.
- 55. R. Kurant and Gilbert/Hilbert. Methods of mathematical physics,

- Vol. 1, ONTI, 1933.
- 56. Zh. Layanis. Stresses and deformations, which appear in the solid fuels during the storage. "Rocket engineering", 1962, No. 4.
- 57. Ye. G. Li. Suppression of the cracking of armored rocket propellant grain. "Rocket engineering", 1962, No. 6.
- 58. D. Lloyd, M. Lipov. Reliability. Organization, research, methods, mathematical apparatus. "Sov. radio", 1964.
- 59. D. Lloyd, Germane, Corcoran. Methods of evaluation and increasing the reliability of large RDTT in the development stage. "Questions of rocket engineering", No. 3, 1968.
- 60. A. I. Lur'ye. Spatial problems of the theory of elasticity. GITTL, M., 1955.
- 61. Young. Maxwell. Large solid-propellant rocket engines. "Questions of rocket engineering", IIL, 1962, No. 1.
- 62. N. I. Malinin. Plastic deformations and creep of the seamless-forged rotors of turbomachines. Calculations for strength No. 6, Mashgiz, 1960.
- 63. Intercontinental ballistic missile "Minuteman" of firm "Boeing", "Questions of rocket engineering". IL, No. 6, 1963.
- 64. U. R. Millz, Zh. R. Haas. Dynamics of rocket "Minuteman" with launch from silo and in flight. "Questions of rocket engineering". IL, 1967, No. 2.
- 65. N. I. Muskhelishvili. Some fundamental problems of the mathematical theory of elasticity. "Science". M., 1966.
- 66. N. I. Muskhelishvili. Some fundamental problems of the mathematical theory of elasticity. PMM, 1952, No. 8.

- 6. Neyber. Stress concentration. M., 1947.
- 68. V. V. Novozhilov. Theory of elasticity. M., State Technical Press, 1950.
- 69. B. V. Orlov, G. Yu. Mazing. Thermodynamic and ballistic bases of the design of solid-propellant rocket engines. Mashinostroyeniye, 1968.
- 70. P. F. Paplovich. Theory of elasticity. Oborongiz, 1939.
- 71. D. A. Pogorelov. Theory of the Keplerian motions of flight vehicles. Fizmatgiz, 1961.
- 72. A. M. Polovko. Bases of the theory of reliability. "Science", 1965.
- 73. V. Pugachev. Theory of random functions and its application to the problems of automatic control. Publ. 2. Fizmatgiz, 1960.
- 74. Yu. N. Rabotnov. Some questions of the theory of creep. Herald of MGU. 1948, No. 10.
- 75. Development of large RDTT in USA. "Questions of rocket engineering". IL, 1966, No. 3.
- 76. "Rocket engineering and cosmonautics", 1964, No. 4.
- 77. V. G. Rekach. Manual on the solution of problems by the theory of elasticity. M., "Higher school", 1966.
- 78. A. A. Sveshnikov. Applied methods of the theory of random functions. "Science", 1968.
- 79. A. A. Silayev. Spectral theory of the spring system of cargo vehicles. Mashgiz, 1963.
- 80. A. M. Sinyukov, N. I. Morozov. (ed.). Construction/design of the guided ballistic missiles. Voenizdat, 1969.

Page 505.

81. A. Sinyukov, E. P. Oganov. Thermoelastic stresses in heterogeneous cylinders and disks of constant thickness. Theses of reports of the VIII scientific report on the thermal stresses in the elements of constructions. Kiev, "Naukova Dumka", 1967.

- 82. A. M. Sinyukov, E. P. Oganov. Thermal stresses in a heterogeneous cylinder of finite length. The "Mechanics of polymers", 1968, No. 4.
- 83. V. I. Smirnov. Course of advanced calculus. Volume III. ONTI, M.-L., 1939.
- 84. N. V. Smirnov, L. N. Bol'shev. Table for calculating the functions of two-dimensional normal distribution. Publishing house of the AS USSR, 1962.
- 85. N. V. Smirnov and I. V. Dunin-Barkovsky. Course of the probability theory and mathematical statistics for technical applications. Iss. 2. Science, 1965.
- 86. P. Solomin. Stress-strain state in the cylinder, attached over the lateral surface, under its own weight. Collection of works on hydromechanics and theory of elasticity. The scientific notes of Tomsk university, No. 68, 1967.
- 87. Statistical forecasting of warranty periods of operation of propellant/fuel charge of third stage of rocket "Minuteman".
  "Questions of rocket engineering", IIL, 1968, No. 9.
- 88. Table of associated functions of V. Ts. Legendre. Publishing house of the AS USSR, 1962.
- 89. L. N. Ter-Mkrtich'yan. Some problems of the theory of the

elasticity of heterogeneous elastic media. PMM, volume XXV, Iss. 6, 1961.

- 90. S. P. Timoshenko, S. Voykovskiy-Kriger. Plates and shells. Fizmatgiz, 1963.
- 91. A. I. Tobol'skiy. Properties and structure of polymers. M., "Chemistry", 1964.
- 92. S. Wilkes. Mathematical statistics. "Science", 1967.
- 93. H. K. Whitfield. Construction of metal housings of RDTT.
  "Questions of rocket engineering", 1969, No. 3.
- 94. A. P. Fedotikov. Short manual of technologist-mechanical engineer, M., Oborongiz, 1960.
- 95. V. I. Feodos'yev, G. B. Sinyarev. Introduction to rocket engineering, M., Oborongiz, 1961.
- 96. J. Ferri. Viscoelastic properties of polymers. IIL, M., 1963.
- 97. M. Ye. Forney, R. R. Parmerter. "Rocket engineering and cosmonautics". No. 3, 1965.
- 98. J. Khedli. Nonlinear and dynamic programming. "Mir", 1967.
- 99. Yu. V. Chuyev (ed.). Bases of operations research in the military technology. "Sov. radio", 1965.
- 100. Ya. M. Shapiro, G. Yu. Mazing, N. Ye. Prudnikov. Bases of the design of solid fuel rockets. Voenizdat, 1968.
- 101. Yu. N. Shevchenko. Axisymmetric problem about the thermal stresses with the variable/alternating modulus of elasticity.

  Candidate dissertation. Kiev, 1958.
- 102. Ya. B. Shor, F. I. Kuz'min. Table for analysis and control of reliability. "Sov. radio", 1968.

- D. I. Sherman. PMM, XV, Iss. 3, 1951. 103.
- Ya. B. Shor. Statistical methods of the analysis of quality 104. control and reliability. "Sov. radio", 1962.
- Shreyder. Method for statistical testing (Monte Carlo 105. Yu. A. method). Fizmatgiz, 1962.
- 106. Aifreu T. Non-homogeneous stresses in visco-elastic media, "Quart-Appl. Math., II, 113-119, 1944.
- 107. Andreosky E. Functional Design of the Minuteman Flight Control Sistem. SAE/NASA Aerospace Vehicle Flight Control Conference; Iuly, 13—15, 1965.

  108. Aviation Week, 1964, vol. 81, N 12.

  109. Aviation Week, 1962, vol. 77, N 18.

  110. Aviation Week, 1963, vol. 79, N 22.

  111. Aviation Week, 1967, vol. 87, N 23.

  112. Aviation Week, 1968, vol. 89, N 9.

## Page 506.

- 113. Aviation Week, 1962, vol. 77, N 26.
- 114. Aviation Week, 1963, vol. 79, N 10.
- 115. Barlow R. F. Proschan F., Scheuer E. Estimation under reliability growth. 125-th annial meeting of the ASA. Philadelphia, Sep. 8—11, 1965.
  116. Bills K. W., Svob G. I., Plank R. W., Eriksson T. L. A Gumulative—
- Damage Concept for Propellant Liner Bonds and Its Application to Solid Rocket Motors. "AIAA 9-th Solid Propellant Rocket Conference", Paper N 65-191, 1 - 13.
- 117. Bolls K. W., Svob G. I., Planck R. W., Eriksson T. L. A Gumulative-Damage Concept for Propellant-Liner Bonds and Its Application to Solid Rocket Motors "AIAA 6th Solid Propellant Rocket Conference", Paper N 65-191.

  118. Chemical Engineering News, 1963, v. 41, N 39.

  119. Daniel M., Pletin M. Simulation de separation d'etages de fusee, "La
- Recherche Aeroapatiale", 1965, N 107.
  - 120. Design News, 1963, vol. 18, N 4.
  - 121. Electronic News, 1965, vol. 10, N 473. 122. Electronic News, 1966, vol. 11, N 534. 123. Engineering News-Record, 1963, vol. 170, N 12. 124. Flight, 1963, vol. 83, N 2820. 125. Flight, 1961, vol. 80, N 2735.
- 126. Flight, 1961, vol. 80, N 2747. 127. Haire E. T. Titan 11 structures reliability analysis. Proceedings of the sixth symposium on ballistic missile and aerospace technology, v. 1, N 9, London, Academic Press, 1961.
  - 128. Halperin M. Annals of Mathem. Statistics, 1952, vol. 23, N 2.
- 129. Hilton H. H. Thermal stresses in bodies exhibiting temperature dependent elastic properties. "Journal of Appl. Meck.", vol. 19, Sept., 1952.
  - 130. Interavia Air Letter, 1964, N 5421.
- 131. L.N.st. Iames Economics Dictates Reliability IEEE Transactions on Aerospace, 1964. IV, N 2, vol. AS-2.

- 132. Journal of Spacecraft and Rockets, 1966, 3, N 3.
- 133. Journal of Spacecraft and Rockets, 1966, 3, N, 9.
- 134. Journal of Spacecraft and Rockets, 1966, 3, N 8.
- 135. Iron and Steel Engineer, 1965, vol. 42, N 10.
- 135. Iron and Steel Engineer, 1965, Vol. 42, N. 10,
  136. Kertesz T. Correlation between Polaris Grund and Flight Test Shock and
  Vibration Data. "AIAA Paper" N 65—206.
  137. Langill A. W., Kapandritis G. N. Multi Component Test Fixtures For
  Solid Rocket Motor Testing. "IEEE Transactions on Aerospace", 1963, I. N 2.
  138. Luftfahrttechnik Raumfahrttechnik, 1968, N 10.
  139. Mc Carthy I. F., Hanley G. M. Earth entry at Hyperbolic velocities.
  "AIAA Paper", 1968, N 153.
  140. Missilus and Rockets 1964, vol. 15, N 24.
- - 140. Missiles and Rockets, 1964, vol. 15, N 24. 141. Missile Space Daily, 1967, vol. 26, N 9.
  - 142. Missiles and Rockets, 1964, vol. 14, N 12.
  - 143. Missiles and Rockets, 1963, vol. 12, N 14. 144. Missiles and Rockets, 1964, vol. 14, N 26.

  - 145. Missiles and Rockets, 1965, vol. 16, N 2.
  - 146. Missile/Space Daily, 1963, vol. 12, N 21,
  - 147. Missile/Space Daily, 1964, vol. 7, N 36.
  - 148. Missile/Space Daily, 1966, vol. 19, N 36.
  - 149. Pieruschka E. Principles of Reliability. Prentice Hall. Inc. 1964,
  - 150. Science New Letter, 1963, vol. 83, N 4.
- 151. Scheuer E. M., Barlow R. E. Reliability grouth during a development testing program. Technometrics, vol. 8, N 1, 1966.
- 152. Shapery R. A. Approximate methods of transform inversion for viscoelastic stress analysis. Graguate Aeronautical Lab, California Institute of Technology SM62-2 (January, 1962).
  - 153. Space/Aeronauties, 1966, vol. 46, N 1.

  - 154. Technology Week, 1967, vol. 20, N. 7. 155. Technology Week, 1966, vol. 19, N 3,

## Page 507.

- 156. Technology Week, 1966, vol. 18, N 26,
- 157. Technology Week, 1967, vol. 20, N 17.
  158. Tormey I. F., Britton S. C. Effect of Cyclic Loading on Solid Propellant Grain Structures "AIAA Journal", 1963, 1, N 8.
  159. Ubrich I. R., Photographic Strain Measurement Technique. "AIAA 9th Solid Propellant Rocket Conference"; Paper N 65—170, 1—20.
  160. Van Der Maas C. I. Multivariate Statistical Analysis of Wind Sounding Data Journal of Spaceraft and Pockets 1967. N 1

- Data. Journal of Spacecraft and Rockets, 1967, N 1.

  161. Wilks W. E. A-G finds filament Wound Minuteman cases would be lighter than expected. Missilcs and Rockets", 1964, 15, N 2.

### DISTRIBUTION LIST

### DISTRIBUTION DIRECT TO RECIPIENT

ORGANIZATION	MICROFICHE	
C509 BALLISTIC RES LAB	1	
C510 R&T LABS/AVEADCOM	1	
C513 ARRADOOM	1	
C535 AVRADCOM/TSARCOM	1	
C539 TRASANA	1	
Q591 FSTC	4	
Q619 MSIC REDSTONE	1	
Q008 NTIC	1	
E053 HQ USAF/INET	1	
E404 AEDC/DOF	1	
E408 AFWL	1	
E410 AD/IND	1	
F429 SD/IND	1	
POO5 DOE/ISA/DDI	1	
P050 CIA/OCR/ADD/SD	2	
AFIT/LDE	1	
NOIC/OIC-9	1	
CCV	1	
MIA/PHS	1	
LLYL/CODE I~309	1	
NASA/NST-44	1	
NSA/T513/TDL	2	
ASD/FID/ITIA	1	
FSL	1	